2017 REPPIR Report of Assessment

Torness Power Station

Contents

Statement of Redaction

It has been necessary to remove a small amount of sensitive information from this publically available Report of Assessment. The redaction of this information has been undertaken in accordance with Regulation 16(6) of REPPIR and with the approval of the Office for Nuclear Regulation.

1. Preface

The nuclear power industry in the UK has a long history of safe operation. The safety standards used in the design, construction, operation and maintenance of nuclear installations reduce to a very low level the risk of accidents that could have a consequence for the general public. Nonetheless, prudence requires the preparation of plans for dealing with such events. The Nuclear Installations Act, controls the activities on civil nuclear installations in the UK, and requires, under the license granted, that adequate emergency arrangements are in place.

The UK, as a member state of the EU, introduces legislation to implement Council Directives. To implement the articles on intervention in case of radiation emergency in Council Directive 96/29/Euratom on the Basic Safety Standards Directive for the protection of the health of workers and the general public against the dangers arising from ionising radiation (the BSS96 Directive) the Radiation (Emergency Preparedness and Public Information) REPPIR 2001 and Ionising Radiation Regulations 1999 have been made under the HSWA 1974 (except REPPIR Regulation 17 which is made under the European Communities Act 1972).

Emergency Preparedness for accidents that may affect members of the public involves many external organisations, such as the local authorities and emergency services. The REPPIR regulations have been developed alongside two other pieces of legislation, the Control of Major Accident Hazards Regulations and the Pipeline Safety Regulations. It is considered beneficial to responding organisations if legislative requirements for emergency preparedness, which affect them, are similar for different industries. Also some operators are active in more than one of these major hazard sectors. The introduction of REPPIR did not replace the requirements of the Nuclear Installations Act, but consolidated and enhanced the approaches taken to emergency planning for accidents at Torness Power Station.

The principal hazard to the public from most accidents at nuclear power stations will be the release of materials that emit ionising radiation. The risk to people and the health effects from exposure to ionising radiation have been the subject of intensive study and research for many decades. The results of this work have been used by the International Commission on Radiological Protection [ICRP] to make recommendations on the principles to be adopted for protection against ionising radiation and a system of dose limitation, both for people exposed to radiation at work and for members of the public in the event of accidents.

Everyone is exposed continuously to natural sources of radiation. Many people receive additional low doses of radiation from artificial sources such as medical X-rays. The principal harmful effect of small doses of radiation is to increase the probability of cancer induction in later years, but very high doses can lead to other serious illnesses in the short term. Although a direct relationship between radiation dose and harmful effects has been observed only in people exposed to relatively high doses of radiation, for the purposes of radiological protection it is assumed that any dose of radiation, however small, carries with it some risk to health. In making its recommendation on annual limits of radiation dose to workers and members of the public, the ICRP has used this cautious assumption.

Public Health England - Centre for Radiation, Chemical and Environmental Hazards [PHE-CRCE], an independent statutory body within the UK, has specified Emergency Reference Levels [ERL] using the ICRP recommendations on intervention. ERLs are levels of radiation dose to the public which would justify introducing a given countermeasure to stop people receiving such a radiation dose. The application of the various countermeasures - evacuation, sheltering and the issue of tablets containing stable iodine and the control of foodstuffs and water supplies - are based on these ERLs. The PHE-CRCE has balanced the risk from the potential radiation exposures and those that may be associated with the implementation of any of these countermeasures.

In the event of an emergency, current legislation requires the following five aspects to be included in the emergency response:

a) the control of the accident at the site
b) the assessment of the actual and potential accident consequences and alerting the relevant authorities and the public
c) introduction of countermeasures to mitigate the consequences as regards [i] individuals who could be affected in the short term and [ii] longer-term effects such as the contamination of food supplies, land and adjoining waters
d) information to the public affected or likely to be affected by the event
e) the return to normal conditions

The Emergency Plan in place for Torness Power Station is currently approved as adequate to deal with the items above. The Emergency Plan is based on fault study analysis and is drawn up against a Reference Accident for the site. The first concern is always to avoid any exposure to the public to radiation and therefore to rectify the fault before there is any danger to the public outside the site. Nevertheless, as soon as the fault occurs, the question of emergency action has to be considered and pre-determined actions, which might eventually lead to notification of off-site agencies and the public, would begin. Emergency actions to protect the public may therefore be initiated in circumstances where the accident does not develop to a stage that has significant off-site consequences.

Currently the emergency actions are based on (a) releases from a Reference Accident and (b) the principle of extendibility for releases beyond the design basis accidents.

a) The releases from a Reference Accident are used to define a zone closely surrounding the installation within which arrangements to protect the public by introducing countermeasures are planned in detail.

b) Emergency Plans need to be capable of responding to accidents which, although extremely unlikely, could have consequences beyond the boundaries of the area identified in (a) above, i.e. extendibility. The measures that are required to extend the detailed arrangements cannot be precisely planned because the nature and potential of accidents can vary, for example according to weather conditions, and the exact response would be based on an assessment made at the time. The response may make use of local and national plans prepared to deal with a wide range of emergencies.

In an emergency, those who normally provide services/carry out protective functions for the public will continue to do so but in a co-ordinated manner which has been carefully planned and rehearsed. A considerable number of different authorities will be engaged, each applying its expertise to the situation as it develops. This off-site emergency response depends on:

a) co-ordination, both locally and nationally, between centres dealing with public protection and information and those dealing with the incident on the site, and
b) in particular both a local and national facility for co-ordinating information and making public the best assessments that can be made

The national response for dealing with a nuclear accident follows the key principles applied by Government in responding to any civil emergency. Firstly, the initial response should be at a local level where control of an accident and its most immediate effects can be dealt with effectively. Secondly, there should be a single lead department to coordinate the Government's response at the national level. For nuclear emergency planning, the lead department is the Department of Business, Energy and Industrial Strategy (BEIS). This responsibility is not devolved for Scotland but the Scottish Government holds some resilience functions for nuclear emergency planning.

2. Purpose

As a nuclear licensed site under the Nuclear Installations Act, Torness Power Station is required to "make and implement" adequate emergency arrangements (Licence Condition 11). The site also falls under the Radiation Emergency Preparedness and Public Information Regulations (REPPIR) which among other things require site operators to undertake a Hazard Identification and Risk Evaluation (HIRE) process. The purpose of the HIRE process is to identify if a radiation emergency could occur at the station, and if yes, whether a radiation emergency is reasonably foreseeable.

EDF Energy is required to prepare and submit a "Report of Assessment" on the results of the HIRE process to enable the Office for Nuclear Regulation (ONR), the UK nuclear regulator, to determine the area to be covered within the local authority's off-site plan for the site.

A Report of Assessment for Torness Power Station was last submitted to the ONR in April 2014. Under the regulations the operator is required to review the HIRE position every 3 years and if appropriate confirm that no change has occurred which affects their previous assessment. If a "material change" has occurred the operator must prepare a revised assessment.

There has been no "material change" to EDF Energy's assessment of the previously assessed hazards and risk from this power station. However EDF Energy has chosen to resubmit a full Report of Assessment based on learning from the submission for Sizewell B Power Station in 2014.

This Report of Assessment follows the regulatory requirements set out in Schedule 5 of REPPIR which detail the minimum content of the report.

It is important to be clear over the extent of current nuclear emergency planning at Torness Power Station. Although the focus is frequently the "Off-Site Emergency Planning Area" (previously referred to as the Detailed Emergency Planning Zone (DEPZ)), this is only one element within the off-site plans.

The Off-Site Emergency Planning Area is the area where detailed plans are required to manage the consequences of an off-site nuclear emergency which would include the provision of urgent countermeasures. Plans for other less urgent but equally important reassurance and protective measures (such as food restrictions) extend beyond the Off-Site Emergency Planning Area and will continue to do so. Furthermore, it has long been a principle in UK nuclear emergency planning that these detailed plans should provide a basis for a wider response, calling on more general contingency arrangements and other resources where necessary. This is the principle of "extendibility".

3. Background

Torness Power Station emergency plans, including the previous Off-Site Emergency Planning Area of 3km have existed since the site was commissioned in 1988.

The scale of off-site planning at Torness Power Station was initially determined by the characteristics of what was previously called the "maximum credible accident" for the design of the Torness AGR Reactor.

Torness Power Station is not sited alongside a Magnox station and therefore there has been no influence over the determination of the Off-Site Emergency Planning Area.

Since the REPPIR regulations came into force in 2001, the licensees for the Torness Power Station site have provided submissions to the nuclear safety regulator drawing on the work that was carried out to satisfy that same regulator under their existing Site Licence Conditions. This led to the Hazard Identification and Risk Evaluation process and Report of Assessment for Torness Power Station that was provided in accordance with the new REPPIR regulations continuing to provide the basis on which the extent of the Off-Site Emergency Planning Area and the wider off-site planning for the Torness site were determined.

Following the Fukushima accident in 2011, the Government asked ONR's Chief Nuclear Inspector to report to it on the lessons for the UK. Two substantial reports [Ref. 3 & 4] were published. ONR's Chief Inspector also led the International Atomic Energy Agency's team that visited Japan after the accident – a visit that led to a further authoritative report [Ref. 5].

In common with other UK operators, EDF Energy has itself initiated work to examine and address the lessons from Fukushima. Where relevant, this report also refers to these Fukushima reports and the conclusions within them relevant to the identification of the Reference Accident for Torness Power Station.

In August 2013 ONR published a new Technical Assessment Guide [Ref. 6] to aid its inspectors when reviewing submissions under REPPIR. EDF Energy has also taken note of this document when producing this report.

4. Report of Assessment

This Report of Assessment has been developed to correspond to the specified content set out in Schedule 5 of REPPIR [Ref.7]. Thus the topic heading follow those within Schedule 5 and in the same order for ease of navigation and reference.

This Report of Assessment is intended to be a distilled content of the HIRE process and as such makes reference to multiple technical documents rather than replicate existing information.

4.1 Operator Details

The name and address of the Operator of Torness Power Station is:

EDF Energy Nuclear Generation Ltd
Barnett Way
Barnwood
Gloucester
Gloucestershire
GL4 3RS

4.2 Premises Details

The postal address of Torness Power Station is:

EDF Energy Nuclear Generation Ltd
Torness Power Station
Dunbar
East Lothian
Scotland
EH42 1QS

4.3 Date of commencement of work with ionising radiation

Work with ionising radiation has already commenced at Torness Power Station. The station was commissioned in 1988. It started generating electricity on 25 May 1988.

4.4 Local area information

This section sets out the local geographical and environmental information for the area immediately around Torness Power Station.

Geographical information

Torness Power Station is situated approximately 8km south east of Dunbar on the coastal plain at Torness Point, just outside the Forth estuary. The site is bounded on the landward side by the A1 trunk road to the south west, by farm land and an access road to the south east, and by a restored quarry to the west.

On the seaward side to the north and east, the site is bounded by foreshore with sea defences constructed as part of the programme of work for the existing nuclear power station, and comprising a sea wall behind dolos units generally to the north and north east and rock to the east and south east. Below the high water mark the foreshore is generally bare rock with scarps and channels, and a cobble strewn beach above. At the southern boundary, near Thorntonloch, there is a narrow sandy beach backed by sand dunes.

Torness Power Station is located within East Lothian Councils administrative boundaries and in the Aird and Loch Ness ward/electoral division. The station is located approximately on Ordnance Survey Grid Reference NT745751.

Meteorology
[Ref.8]

Mean annual temperatures over the region vary from about 9°c close to the Firth of Forth to less than 6°c over the higher ground of the Grampians. Within the region, significant variations in temperature arise from the combined effects of proximity to the coast, topography and, to a lesser extent, urban development.

January is the coldest month, with mean daily minimum temperatures varying from about 2°c in areas of East Lothian and Fife bordering the Firth of Forth and on the NE coast of Grampian, to less than -2°c over the higher ground. Extreme minimum temperatures usually occur in January or February.

July is the warmest month, with mean daily maximum temperatures at low levels inland approaching 20°c, the highest in Scotland. Elsewhere in Eastern Scotland the mean maxima are somewhat lower, and are less than 17°c over the higher ground and along the coast of Grampian region. Extreme maximum temperatures can occur in July or August, and are usually associated with heat-waves.

An 'air frost' occurs when the temperature at 1.25 metres above the ground falls below 0°c, whereas incidence of a 'ground frost' refers to a temperature below 0°c measured on a grass surface. The average number of days with air frost in Eastern Scotland varies from less than 40 a year on the coast of Fife to more than 90 a year over the higher ground of the Lammermuir Hills and Grampians. Ground frost averages range from less than 90 to over 150 days per year, with a similar distribution to air frost. However, those places into which cold air can drain are particularly prone to frost. Examples include the deep valley of the River Dee around Braemar which lies well within the Grampian Mountains.

Eastern Scotland includes the sunniest places in Scotland, these being on the coast of Fife where the average is about 1500 hours per year. Other coastal places, for example in East Lothian, average more than 1400 hours but sunshine averages are lower elsewhere, and are lowest over the Grampian mountains (less than 1100 hours).

The sunniest month is May, rather than June, because of the tendency for settled anticyclonic conditions in late spring which is a feature of the weather over Scotland as a whole. However, this national trend is less marked and even reversed at places close to the east coast because of the occurrence of sea-fog (haar) in late spring. Here, June is marginally sunnier than May.

Much of Eastern Scotland is sheltered from the rain-bearing westerly winds. This shelter reaches its greatest potential along the coasts of East Lothian, Fife and the Moray Firth and these areas receive less than 700mm of rainfall in an average year. In contrast, the wettest area is the southern Grampians where the average annual rainfall is over 1500mm.

Rainfall is generally well-distributed throughout the year. The frequency of Atlantic depressions is normally greatest during the autumn and winter but, unlike other parts of the UK, Scotland tends to remain under their influence for much of the summer too. The wettest months tend to be in autumn and early winter, whereas late winter and spring is normally the driest part of the year.

Over much of Eastern Scotland, the number of days with rainfall totals of 1mm or more ('wet days') tends to follow a pattern similar to the monthly rainfall totals. In winter (December to February), there are about 30 wet days on average along the coasts of East Lothian and Fife, rising to over 55 days in the Grampian mountains. In summer (June to August) the East Lothian and Fife coasts have about 27 wet days and the Grampian Mountains over 40 days. Periods of prolonged rainfall can lead to widespread flooding, especially in winter and early spring when soils are usually near saturation and snowmelt can be a contributing factor.

Over most of the area, snowfall is normally confined to the months from November to April, but upland areas often have brief falls in October and May. Snow rarely lies at lower levels outside of the period November to April.

On average, the number of days with snow falling is about 20 per winter along the coast but over 80 days over the Grampians. The number of days with snow lying has a similar distribution, with less than 10 along the East Lothian coast but over 60 days over the higher ground of Grampian. These averages can be compared with the coasts of SW England where less than 3 days per year have lying snow.

Eastern Scotland is one of the more windy parts of the UK, being relatively close to the track of Atlantic depressions. The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter half of the year, especially from December to February, and this is when mean speeds and gusts (short duration peak values) are high.

Another measure of wind exposure is the number of days when gale force is reached. If the wind reaches a mean speed of 34 knots or more over any ten consecutive minutes, then that day is classed as having a gale. Over most inland areas of the region the average is around 5 days per year but places sheltered to the west experience fewer than this and well exposed upland areas have over 20 days with gale in an average year. Wind speed is sensitive to local topographic effects and land use. Exposed places on coasts and hills will experience stronger wind speeds and more days of gale. The highest wind-recording station in the UK is on Cairngorm (1245 metres) which holds the record for the highest gust (150 knots on 20 March 1986).

Spring time tends to have a maximum frequency of winds from the north east. In Eastern Scotland, periods of very light or calm winds with no preferred direction vary from about less than 1% of the year on the coast to about 5% at sheltered places well inland. The annual wind rose for Leuchars is typical of open, level locations across the Central Lowlands, with an enhanced south-westerly wind direction through the year associated with a large-scale funnelling effect. In marked contrast, places further north, to the lee of the Grampian Mountains, experience diminished south-westerlies as air is deflected by the high ground to the west. The annual wind rose for Aberdeen airport (Dyce) is typical of this area. However, in all areas there tends to be a higher frequency of north to north-east winds in spring.

Geology and hydrology
Section reference: [Ref.9] [Ref.10]

Torness Power Station is located on the East Lothian coast on the margin of the Midland Valley, a late Palaeozoic graben structure. The Midland Valley rift is filled with Devonian and Carboniferous sediments and lavas, and the rocks of Silurian age (earlier Palaeozoic).

Rocks of the Carboniferous Limestone series outcrop on the coast and extend inland for about 3km, where the strata are faulted against rocks of the Upper Old Red Sandstone (Devonian). The rocks are overlain by raised beach deposits, and post glacial sands and gravels overlying glacial till, which comprises stiff or very stiff sandy silty clay and some gravel.

The rock strata are divided into the Lower Limestone Group and Calciferous Sandstone Measures of the Midland Valley Classification. Both consist generally of interbedded limestones, sandstones, mudstones and siltstones, with some measures of coal and seatearth. The general succession in the Torness area is as follows:

Superficial Deposits	Raised beach deposits	1 to 3m thickness
	Post-glacial sand and gravel	1.5 to 8m
	Post-glacial sand	1 to 5m
	Glacial till	1 to 8.5m
Lower Limestone Group	Chapel Point Limestone	1.5 to 2m thickness
	Chapel Point Sandstone	14m
	Calcareous mudstone with three impersistant lenticular limestone bands	7 to 10m
	Middle Skateraw Limestone (MSL)	4 to 5m
	Coal, seatearth and mudstone	3 to 4m
	Lower Skateraw Limestone (LSL)	0.7 to 1.35m
	Coal and seatearth	0.6m
	Sandstone and argillaceous partings	4.5 to 5m
	Upper Longcraig Limestone (ULL)	7 to 7.5m
Calciferous Sandstone Measures	Calcareous siltstone, coal and seatearth	1.5 to 2m thickness
	Middle Longcraig Limestone (MLL)	0.8 to 1.5m
	Crossbedded sandstones with bands of siltstone and occasional mudstone and coal	5 to 7m
	Lower Longcraig Limestone (LLL)	
	Crossbedded sandstones with occasional siltstones and mudstones	2.5 to 4m
		penetrated to about 60m

Torness Power Station is located on the watershed dividing two catchment areas, that drained by the Dryburn and its tributaries, and that drained by Thurston Mains Burn and Thornton Burn and their tributaries.

The site may be considered to form part of a sub-catchment, within which drainage is principally be percolation to water bearing underlying strata. A smooth sided shallow valley, probably of glacial origins, runs inland. This is generally dry with the exception of a small flow at the eastern (Raised Beach) end.

In general, the water table is indicated as being parallel to, and approximately 1m to 3m below, the current topography (approximately +8.5 to 10mOD) over the inland part of the site and sloping down beneath the raised beach to the east. Some seepage is reported in outcrops on steep faces between 1m and 2m above the high water mark at Torness Point.

Piezometer readings taken on the Dry Fuel Store site between August 1992 and January 1993, show groundwater levels fluctuating slightly between 2.5 and 3.0m below ground level.

4.5 Radioactive substances on site

This section describes the radioactive substances which are present on-site at Torness Power Station in excess of the quantities set out under Schedules 2 and 3 of REPPIR [Ref.7] and where it has been practical to do so, identifies radionuclides present and the likely maximum quantities of these. This section is broken down into the various sources of radioactive material including in use nuclear fuel, spent fuel, on-site stored waste and ancillary sources.

Reactor core fuel

The greater part of the radioactive substances present on site is contained in the irradiated nuclear fuel. In its un-irradiated state (i.e. as brought onto site) the fuel contains very little radioactivity. However, exposure to the nuclear chain reaction and the radioactive decay of the products of that chain reaction causes the fuel to become highly radioactive. The radioactivity of fuel increases with irradiation in the reactor but decays when removed from the reactor.

Torness reactors each contain 114 tonnes of fuel when fully charged. The typical inventory for a single AGR reactor core with zero radioactive decay is shown below [Ref.11]. Torness has two reactors.

Nuclide	Element Inventory
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Spent reactor fuel

Reactor fuel that has been used up is sent for reprocessing or storage at Sellafield. Before this takes place the fuel is held on-site for a period of no less than 90 days to allow it to cool sufficiently for safe transport. Fuel is held in two locations on-site, the first is in the intermediate or "buffer" stores. Buffer stores are used to maintain spent fuel assemblies within a CO_2 atmosphere, cooled by an external cooling water supply until the heat produced by the fuel assembly drops to a level where it can be safely processed through the Irradiated Fuel Disposal route (usually dependent on irradiation). This also allows the short half-life fission products to decay.

During Irradiated Fuel Disposal, the spent fuel assemblies are dismantled, after which the individual fuel elements are transferred to the station's Irradiated Fuel Storage Ponds, and other non-fuel assembly components are sent to the waste vault.

The maximum likely inventories within ex-reactor irradiated fuel on-site are as follows. The radionuclides are generated from [Ref.12].

Nuclide	Maximum Buffer Store Capacity	Maximum Pond Capacity
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Irradiated waste

By their nature, operations at a nuclear power station generate waste, of which some of this is irradiated. Whilst of much lower levels of radiation than the spent reactor fuel, some of these wastes have been identified as likely to be above the limits identified in schedule 2 of REPPIR. These wastes can take either solid or liquid (including sludge) form.

The maximum volumes of waste which could be stored on-site are:

- Solid irradiated waste ~ 3200m³
- Liquid irradiated waste ~ 255m³

Specific quantities of irradiated wastes on-site are recorded and monitored as part of the Nuclear Decommissioning Authorities "UK Radioactive Waste Inventory" [Ref. 13]. The specific waste identified as being above REPPIR schedule 2 levels are:

Stream ID	Waste material	Type
4C02	Desiccant	ILW
4C03	Pond Water Filtration Resin	ILW
4C06	Active Effluent Filtration Resin	ILW
4C12	Miscellaneous Activated Items	ILW

The Waste Inventory Data for Torness, available via the UK Radioactive Waste Inventory, provides the current quantities of each of these wastes, predicted maximum quantities through the life of the plant, material composition and the average radioactive per m³. The full details are not replicated here for purposes of brevity

Reactor components and additional materials

There are a number of additional materials within the station that become irradiated as part of normal plant processes. Some of these materials are fixed in place within structures with no plausible mechanism for release.

Irradiated fuel storage ponds

Activity in the fuel storage pond water potentially arises from leaking of activity from graphite fuel sleeves, fuel clad and fuel clad oxides. This arises as a result of in reactor activation of component elements, impurities and surface deposits. Pin surface activity can also arise from contamination with trace amounts of uranium and activity in deposited graphite. The table below [Ref.14] sets out a likely bounding level of pond water activity based on a volume of based upon a pond volume of 1E+06 litres. It should be noted that pond water would normally be kept at levels significantly lower than these upper limits.

Nuclide	Pond Equilibrium Activity
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Reactor coolant

Through normal operations the CO_2 coolant gas used in the reactor absorbs radioactivity through its contact with the fuel elements.

The activity of the coolant gas is set out below [Ref.15].

Nuclide	Activity In Coolant Gas
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Graphite moderator

Within the reactor, graphite is used to moderate the speed of neutrons given off during the fission process in order to maintain the conditions necessary for a controlled chain reaction. Through the life of the station this graphite is irradiated by the nuclear fuel. The reactors at Torness Power Station contain ~ 2785m³ or 3545t.

Whilst calculating the current radionuclide content is not practical, the forward estimation of this graphite when it becomes waste as part of plant decommission is identified as part of the Nuclear Decommissioning Authorities "UK Radioactive Waste Inventory" [Ref. 13] under stream IDs 4C313 and 4C317. However, it should be noted the activities quoted are for the time at which this waste will arise (i.e. ~85 years after end of generation).

Containment materials

The reactor pressure vessel itself contains materials which have become irradiated through normal operations. Again, whilst identifying specific current activity levels is not practical, the decommissioning estimates identify the quantity of materials and likely activity levels at the time this material becomes waste [Ref 13].

Stream ID	Containment Material	Approximate Quantity
4C311	Stainless Steel (Reactor) ILW	141 m³
4C312	Mild Steel (Reactor) ILW	531 m³
4C314	Stainless Steel (Reactor) LLW	1120 m³
4C315	Mild Steel (Reactor) LLW	3278 m³
4C318	Concrete (Reactor and Non-Reactor) LLW	2789 m³
4C319	Miscellaneous Metals and Materials (Reactor and Non-Reactor) LLW	596 m³

4.6 Site plan and environs map

Figure 1 provides a plan of the site, while Figure 2 shows Torness Power Station in its local context on an Ordnance Survey map.

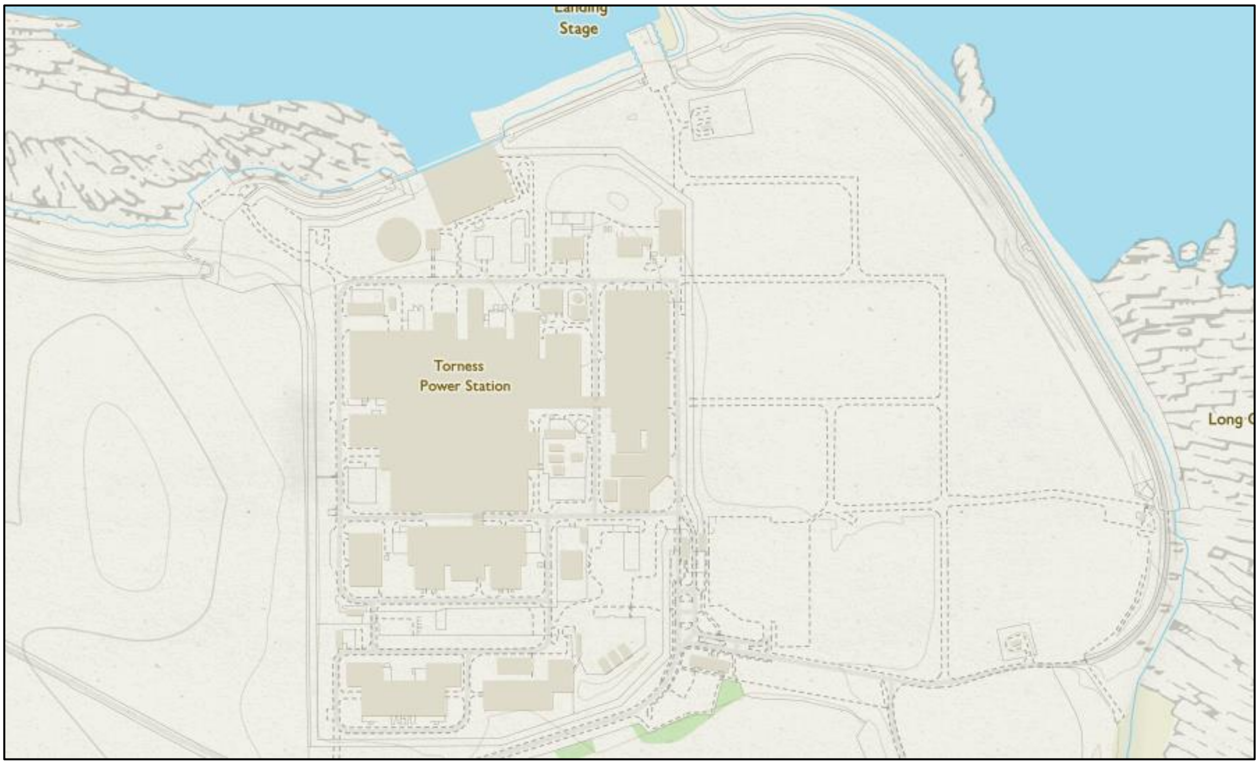

Figure 1 Torness Power Station Site Plan [Ref.16]

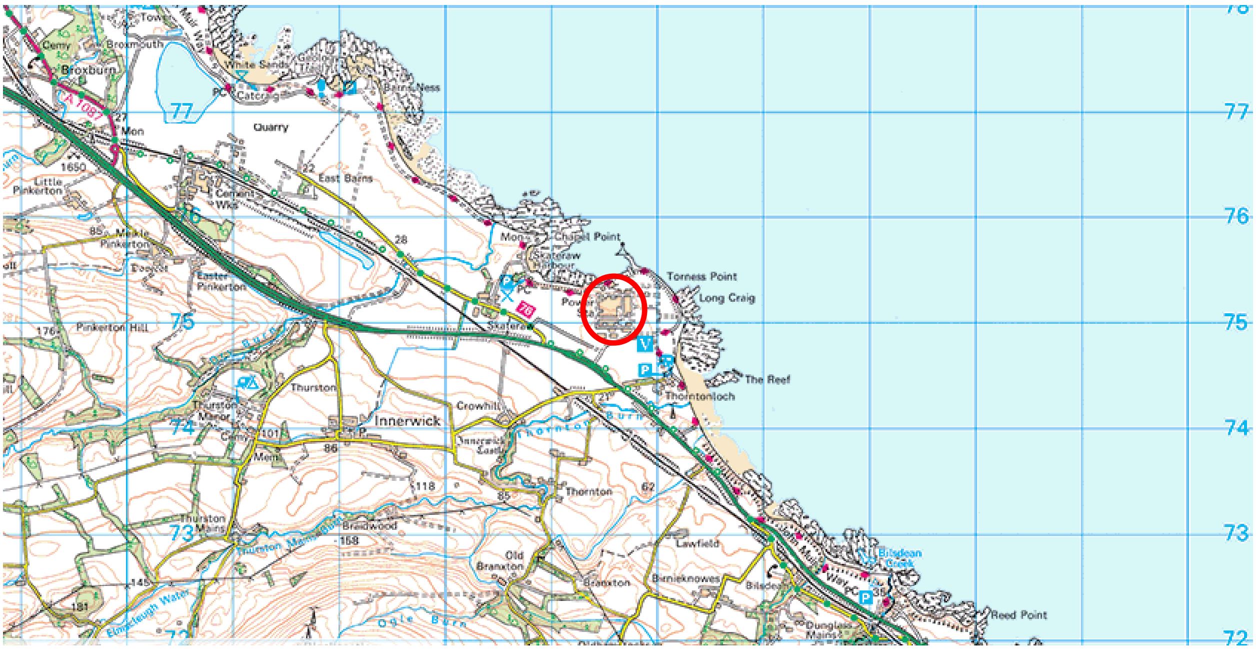

Figure 2 Torness Power Station Environs [Ref.16]

4.7 Plant and enclosed systems

This section details the plant and enclosed systems that contain more than the quantities of radioactive material identified in schedules 2 and 3 of REPPIR. The principal plant and enclosed systems are:

- Reactor Core and Pressure Vessel
- Irradiated Fuel Buffer Store
- Fuel Storage Pond and Pond Water Treatment Plant

PLEASE NOTE – The descriptions of plant items in this section are generic for a typical AGR power station and do not specifically describe the exact plant and systems found at Torness.

Reactor core and pressure vessel

The Reactor core, boilers and gas circulators are housed in a single cavity, pre-stressed concrete pressure vessel, (see Figure 3).

The reactor core is designed to act as a moderator and to provide individual channels for fuel stringer assemblies, control rods and coolant flow.

The reactor core is a massive sixteen-sided stack of graphite bricks. The bricks are interconnected with graphite keys to provide the assembly with stability and to maintain the vertical channels on their correct pitch, despite dimensional changes due to, for example, irradiation, pressure loads or thermal stresses.

The complete assembly comprises an inner cylinder of moderator graphite containing fuel channels surrounded by neutron reflector and shield graphite. The graphite structure is maintained in position by a steel restraint tank surrounding the graphite and is supported on a system of steel plates.

The graphite core is covered by an upper neutron shield of graphite and steel bricks and mounted on a lower neutron shield of graphite bricks that rests on the steel plates. Side shielding is in the form of steel rods located in the two outer rings of graphite bricks. Additional shielding is provided by steel plates fastened to the steel restraint system.

The shielding reduces radiation levels outside the core, so that when the reactor is shut down and depressurised, access is possible to the boilers and all plant inside the reactor vessel, except the plant within the core.

The graphite core and shielding are surrounded by a steel envelope called the gas baffle and supported on a steel grid called the diagrid. The diagrid is, in turn, supported by the peripheral skirt that forms the lower end of the gas baffle cylinder. The main functions of the gas baffle are to produce a downward flow of coolant gas through the core and to separate the hot from the cold gas [Ref.17].

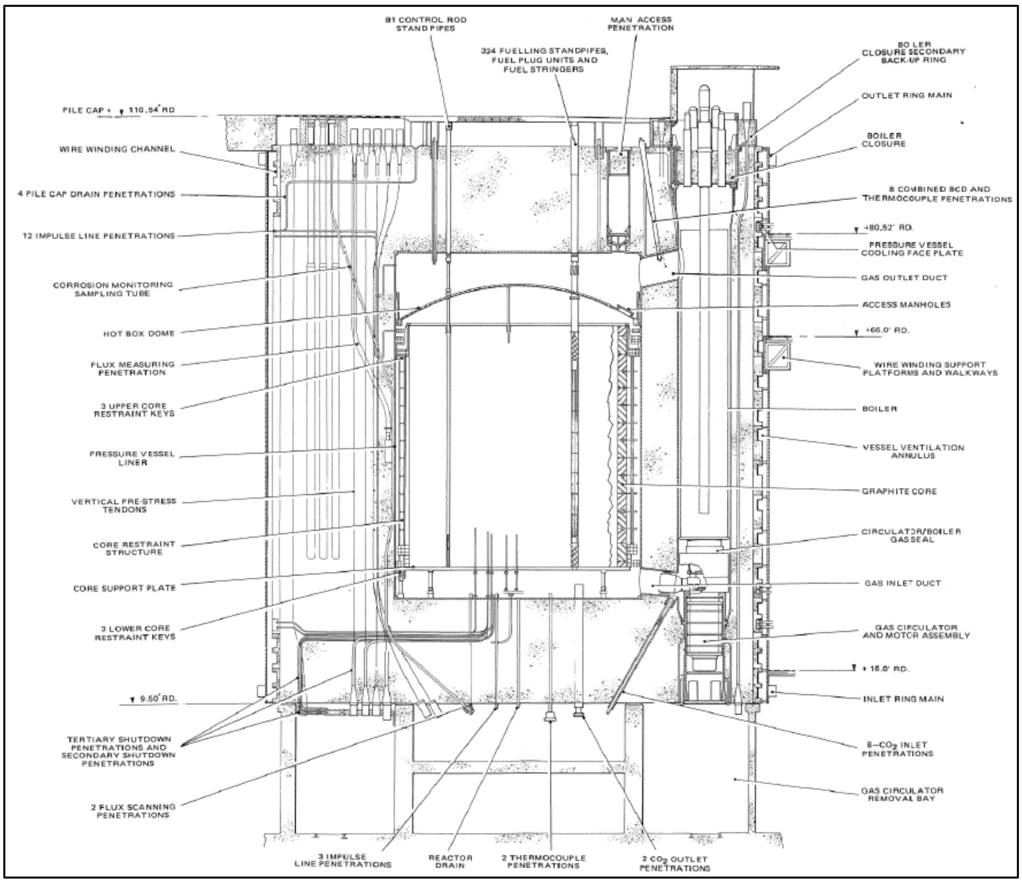

Figure 3 Typical AGR Reactor and Pressure Vessel

Irradiated fuel buffer store

The buffer store acts as an intermediate storage for spent fuel assemblies when they are first removed from the reactor. Due to the heat levels within these assemblies, they cannot immediately be processed through the Irradiated Fuel Disposal route.

The fuelling machine takes spent fuel assemblies from the reactor and lowers them into a decay tube. They remain there, within a pressurised CO_2 atmosphere, cooled by an external cooling water supply until the heat produced by the fuel assembly drops to a level where it can be safely processed through the Irradiated Fuel Disposal [Ref.18].

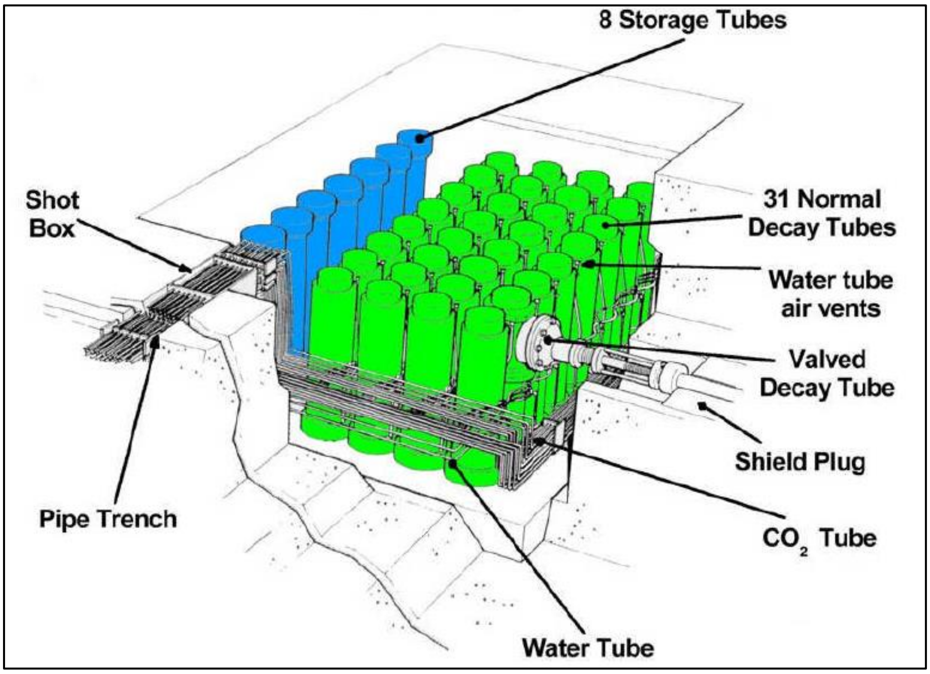

Figure 4 Typical AGR Irradiated Fuel Buffer Store [Ref.18]

Irradiated fuel storage ponds and pond water treatment plant

The purpose of the irradiated fuel storage ponds is to safely store irradiated fuel until the radioactivity and decay heat have reduced to an acceptable level before transportation to Sellafield for reprocessing or storage.

The irradiated fuel storage ponds are used for the storage of irradiated fuel elements discharged from the reactor and then processed through the Irradiated Fuel Disposal (IFD) cell. The pond water provides both shielding and cooling for the fuel during the storage period, before fuel is transported off-site in an Irradiated Fuel Transport Flask (IFTF) [Ref.19].

The pond water, in addition to cooling the fuel, provides the biological shield against gamma radiation from the spent fuel.

The fuel storage ponds are filled with boronated water in the form of boric acid to avoid any possibility of a criticality incident in the pond.

The basic functions and duties of the pond water treatment and cooling plants are as follows:

- to provide sufficient cooling to remove decay heat from stored irradiated fuel
- to maintain a pond water level sufficient to provide the necessary shielding
- to reduce the level of corrosion products by removal of any particulate or soluble impurities formed from the stored fuel
- to maintain the correct boron concentration and pH to reduce the risk of a criticality incident and to prevent corrosion of the fuel pins

It is also important to control pond water temperatures due to some important secondary considerations, one of which is that it will minimise airborne contamination due to reduced evaporation rates. Controlling pond water temperatures also reduces fuel-can corrosion rates as well as the rates that oxides will be dissolved in to the pond water, which is significant from a pond water chemistry viewpoint.

High pond water temperatures also have the potential to cause structural damage to the pond and its lining. Also, sudden chilling of the fuel elements as they enter the pond water, together with possible leaching of fission products from damaged fuel pins, releases oxides and other impurities into the pond water.

Hence, it is necessary to clean and cool the pond water, which is carried out by the Pond Water Treatment Plant (PWTP).

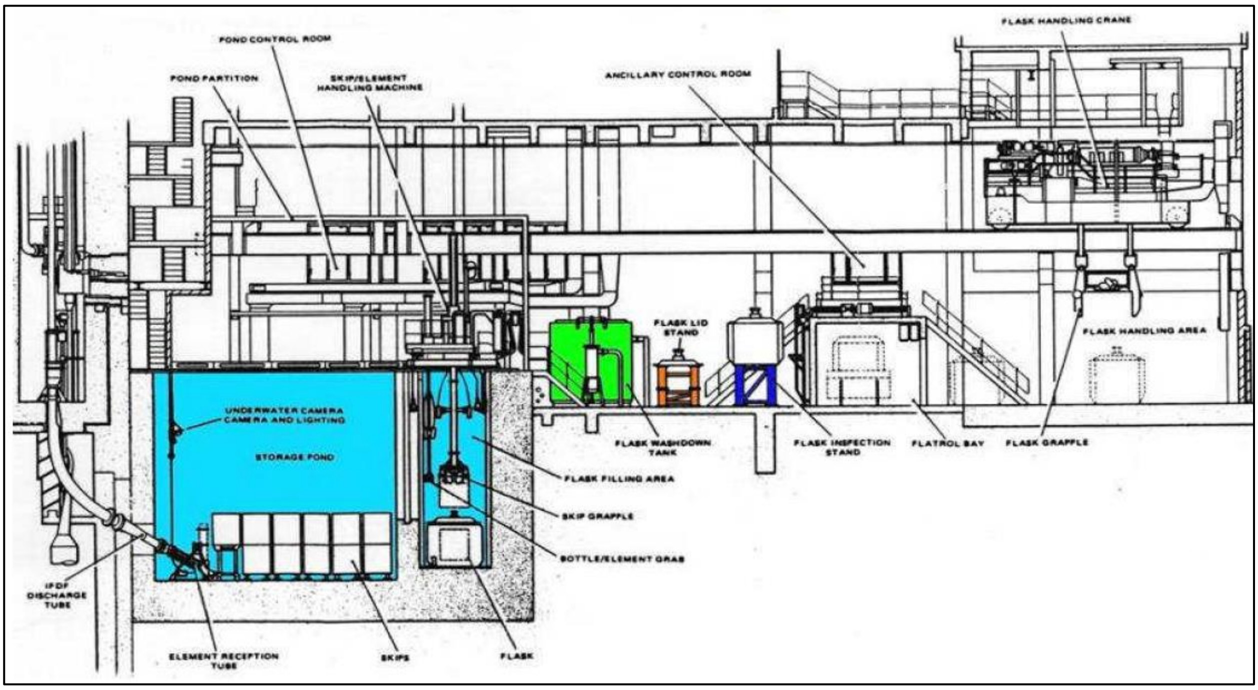

Figure 5 Typical AGR Fuel Storage Pond [Ref.19]

4.8 Factors precipitating a major release of radioactivity

A comprehensive review of the existing EDF Energy method for identifying the factors which could precipitate a major release of radioactivity has been undertaken as part of the HIRE process. The methodology for this review, agreed with the ONR, is set out in the report "HIRE Assessments for the AGRs" [Ref.21].

This involved:

- a review of the current reactor Probabilistic Safety Assessment (PSA) to identify relevant fault sequences that could lead to significant radiological releases
- identification of those faults that could be considered reasonably foreseeable (i.e. those with a frequency >10^{-6} per reactor year)
- examination of identified fault sequences with an emphasis on the pessimisms/conservatisms built into the PSA
- identifying if there are any reasonably foreseeable fault sequences that result in a release above the previously identified AGR reference release
- consideration of faults other than for reactors at power in the Fuel Route and Radioactive Waste Facilities

The review concluded that after comprehensive interrogation of the AGR reactor PSAs, on the basis of the agreed methodology, there is no compelling reason to move away from the previously identified Reference Release as the basis for defining the DEPZ at any of the AGR sites. Faults in non-reactor facilities have been considered, and have been argued not to affect this conclusion.

In line with the methodology described in [Ref.21] a detailed review of the Torness PSA fault sequences was carried out. This document [Ref.22] reviewed sequence information extracted from the Version 3.0 Torness PSA model (TORV30) and sorted to identify sequences with frequencies greater than 10^{-6} per year in each of the Dose Band (DB) 3, DB 4 and DB 5 consequences.

The detailed results of the review are shown in the tables in [Ref.22]. The sequences in each dose band are grouped by fault type in the subsequent discussion of which sequences are either demonstrably shown, or judged, to be bounded by the reference accident (see below).

PSA sequences in Dose Band 3, 4 and 5 with sequence frequencies greater than 10^{-6} per year have been reviewed. For all of these sequences, consideration of pessimisms and conservatisms has shown that the frequency and/or dose is actually lower than assessed within the PSA, thus removing these sequences from consideration as the Reasonably Foreseeable Radiation Emergency.

The reference release was originally identified in [Ref.39]. This was issued following the development of the PSA for the AGRs, and made use of the PSA to consider a wider range of fault sequences/consequences than the previous deterministic approach to defining the DEPZ.

The introduction of the PSA highlighted that there does exist a range of very low frequency sequences that can give rise to very large releases, so that the deterministic concept of a maximum credible accident becomes inapplicable. The conceptual shift was instead to ensure that the frequency of having to implement the Emergency Plan, in order to protect the public by implementing effective countermeasures to avert dose, should be acceptably low.

A reference release was then considered. One of the approaches considered was to identify a release which would only be exceeded in more severe faults with a summed frequency less than 10-4 per annum (taking this as an appropriate value to correspond to “reasonably foreseeable”).

In terms of Safety Review Guidebook release categories, the release is best represented as a multiple (~x3 based on 131I, ~x2 based on 137Cs) of CAT 6. CAT 6 releases of iodine are typically associated with depressurisation faults with failure of Post Trip Cooling, restored after 12 hours. In other words, the reference release does correspond to a very significant fault sequence.

A depressurisation fault with failure of Post Trip Cooling, restored after 12 hours, can be considered as a reference accident for AGRs.

Hazard factors

A hazard is any event that could occur within or outside the site boundary that alters the environment in such a way as to prejudice safety. A hazard can cause a plant fault, or may be a consequence to a plant fault. Accordingly, there is a need to assess the safety of the reactor and its support systems, including Fuel Route, Radiological Waste, and nuclear fuel storage facilities, against the consequences of Internal and External Hazards.

As with any recognised plant fault, it is important to understand how a fault or a hazard can present itself. This is achieved by identifying possible initiating events, the source of those events and the consequences of those events – both in terms of directly challenging the integrity of the reactor and its support system; and also by the initiation of further consequential events.

In 1996, the first systematic review of AGR safety cases against a list of potential hazards was completed as part of the first Periodic Safety Reviews (PSR1) for Hinkley Point B and Hunterston B. PSR1 considered a wide range of potential internal and external hazards explicitly and established the basis for a safety case with respect to these. The list of hazards was further developed as part of PSR2 which confirmed that Nuclear Safety Principal (NSP) 2.4 was consistent with the International Atomic Energy Agency (IAEA) recommendations current at that time, for the consideration of hazards within nuclear safety cases, with the notable exception that drought, biological fouling, electro-magnetic interference and lightning were not included in the NSP listing. The PSR2 formalised the requirement for these four hazards to be brought into the AGR safety cases. In 2013, after operational challenges at Hunterston B during previous years due to volcanic activity in Iceland, and because of increasing concern over the potential impact of solar storms, two new hazards were added: Airborne Particulates and Solar Storms [Ref.41]

The Nuclear Safety Principles (NSPs) require consideration of internal and external hazards in safety cases. The NSPs define the design basis for external hazards as an event with an annual probability greater than or equal to 10^{-4}. Furthermore, the

NSPs require the demonstration that there is no disproportionate increase in risk at reducing annual frequencies, i.e. no "cliff-edge" effect.

The potential hazards for Torness Power Station, along with the rest of the EDF Energy AGR fleet, against which the Station Safety Case is reviewed, have been identified in the following report "Definitions of the Internal and External Hazards for the AGR fleet" [Ref.20]. The report identifies the following internal and external hazards.

Internal and External Hazards for the AGR Stations	
Internal hazards:	External hazards:
Fire	Seismic
Steam Release	Extreme Wind
Hot Gas Release	External Flooding
Cold Gas Release	Aircraft Impact
Missile Impact	Industrial Hazards
Dropped Loads	Extreme Ambient Temperatures
Internal Flooding & Corrosive Fluid Release	Lightning
Toxic Gas Release	Drought
Vehicular Impact	Biological Fouling
Electro-Magnetic Interference / Radio Frequency Interference *(considers external sources also)*	Solar Storms
	Airborne Particulates

A treatment of hazards sequences is included within the Probabilistic Safety Analysis, and the conclusion summarised in the above thus remains applicable when considering hazards as a specific class of fault.

Malicious hazard factors

The threats from malicious activity are not considered as part of the plant Probabilistic Safety Analysis and fault sequence studies reported in [Ref. 21] however the HIRE is required to evaluate all threats, including those of a malicious origin. A judgement is made that there is no significant probability of the conclusions of [Ref.21] being affected by consideration of malicious human activity and therefore that it is not reasonably foreseeable that malicious activity would lead to a radioactive release in excess of that bounded by the AGR Reference Release [Ref.28], for the following reasons.

a. Individual fault sequences which challenge the agreed criterion for "Reasonably Foreseeable" in the PSA/fault sequence studies - i.e. frequencies greater than 10^{-6} pry (per rector year) giving rise to consequences more severe than DB3 - are generally sequences which involve an initiating event followed by complex combinations of plant protection and/or operator actions being unsuccessful in early termination of the sequence. Many of the initiating events involve boiler tube failures, for example. It is judged for these sequences that both the initiating events and the complex combinations would be impracticably difficult to influence deliberately.

b. It is recognised that there are other initiating events which do not typically lead to challenges to the agreed criterion but which it would be more feasible to influence. These are faults against which the implementation of comprehensive Nuclear Site Security Plans, Security Cases and Integrated Protection Solutions are specifically designed to provide protection, and it is judged that these measures can be claimed deterministically to prevent damaging fault sequences.

Consideration of "all hazards arising"

Whilst this report predominantly focuses on the determined reasonably foreseeable reference release and associated faults identified in [Ref.21 &22], REPPIR regulation 4 requires investigation beyond this to encompass "all hazards arising… with the potential to cause an radiation accident". This includes accidents of a significant nature but with very low likelihoods of occurrence.

The methodology used to establish the reasonably foreseeable faults for the HIRE adopts the Probabilistic Safety Analysis (PSA) approach to looking for a reference accident/release. This means that all potential initiating events are considered (notwithstanding the comments in section 4.8.1.1) as part of the process.

The identification of low likelihood, high consequence events within the PSA has been supported by assessment of Beyond Design Basis Accidents [Ref.42]. Beyond Design Basis Accident Assessments conducted for Hartlepool and Heysham 1 (carried forward for Torness) considered faults frequencies up to 10^{-9} per year, which in the absence of operator intervention could lead to significant radiological releases.

The postulated releases to the environment for beyond design basis accidents range over several orders of magnitude up to and including releases that encompass the total release of the core inventory of noble gases and volatile elements such as iodine and caesium and significant fractions of the less volatile and involatile elements.

Using existing severe accident fault studies, considerable work has been completed by EDF Energy, amongst other operators and agencies, since the Fukushima accident in 2011 to identify source terms for severe accidents [Ref. 40]. These include a range of postulated releases that increase in magnitude from the worst reasonably foreseeable accidents specified for REPPIR up to releases of significant fractions of the radioactive inventories.

The identification and analysis of severe accident hazards has enabled the development of response guidelines to tackle the consequences of such events to reduce the release of radiation. As identified by the ONR in their Technical Assessment Guidance – 82 A52 [Ref.6] – the measures to deal with such events cannot be as precisely planned as those for reasonably foreseeable incidents but should provide a framework for the response. The guidelines developed for severe accident management on-site include the Deployable Back Up Equipment Guidelines (DBUEG) [Ref.44 & 45] and Severe Accident Guidelines (SAGs) [Ref.27 & 43].

Off-site, the response to low likelihood, high consequence events is managed through the concept of extendibility which is described in the Off-Site Plan [Ref.34]. This is identified as good practice in the REPPIR guidance [Ref.2].

Protective measures

As an owner and operator of commercial nuclear power plant, EDF Energy is responsible for the safety of its employees and the public in respect of risks arising from normal operation and from any nuclear accident arising from its installations. There is therefore a fundamental legal requirement for risks to be As Low As Reasonably Practicable (ALARP). This responsibility is fully recognised by the Company and leads it to give the highest priority to the maintenance of nuclear safety standards in its nuclear power plants. The Companies approach to nuclear safety is set out in the Nuclear Safety Policy [Ref.48].

The Nuclear Safety Principles, to which EDF Energy conforms, have been defined taking into account the document issued by the Health and Safety Executive (HSE) entitled 'The Tolerability of Risk from Nuclear Power Stations' and subsequently developed further in ‘Reducing Risks, Protecting People’ (R2P2) which reflects current thinking on tolerable levels of risk, both to individuals and to society as a whole. The detail of the Nuclear Safety Principles is set out in Section 4 of the Nuclear Safety Principles for the Safety Review of the AGRs [Ref.26].

A significant number of measures are in place as part of the design and operation of Torness Power Station to reduce the risk of significant radioactive releases occurring. The principle of defence in depth and redundancy is applied to the design of plant and protective systems.

The station operates under a set of parameters defined as the “safe operating envelope” [Ref. 24]. This envelope represents a bounding condition from which fault transients can be assumed to start. The envelopes are defined within the station Safety Cases and used to ensure that the plant always operates within safe parameters.

Protection systems for the reactor are identified in Section 3.3 of the Station Safety Report [Ref.25]. Specific individual protection claims for faults are identified in the Torness Station Safety Review Section D documentation suite.

The response to a within design basis fault would be carried out utilising the post fault Station Operating Instructions (SOIs), and the Symptom Based Emergency Response Guidelines (SBERGs).

The SBERGs give advice in a developing fault situation, for which the normal operating instructions are not valid. This advice focuses on the symptoms of the fault rather than on specific failures in any one plant system. The SBERGs supply guidance on the most appropriate actions which would be needed to preserve and reinforce the critical safety functions, such as reactor cooling.

There are additional measures of protection for severe and beyond design basis accidents as described in section 4.8.1.2 above.

The Station Emergency Arrangements, as required under Site Licence Condition 11, form an integral part of the protective measures. The emergency arrangements are discussed in more detail in section 4.11 and are set out as part of the Site Emergency Handbook [Ref.46] and Site Emergency Plan [Ref.47].

Radioactive substances within a reference release

Details removed from this publically accessible document.

Plant which could precipitate a reference release

All the identified fault sequences identified in section 4.8.2 would originate in the reactor and pressure vessel, described in section 4.7.1.

4.9 Factors precipitating a smaller release of radioactivity

There are a considerable number of fault sequences within the Torness PSA which could lead to a release of radiation at a lower level than those identified in section 4.8.2 These faults can be located in the Torness Periodic Safety Review 1 Section 5.1 [Ref.29]. Typical fault sequences are dominated by the following faults:

- over-pressurisation faults
- depressurisation faults
- reactivity faults

These faults would be controlled using the same measures identified in section 4.8.3.

4.10 Factors precipitating the initiation of a self-sustaining chain reaction

The initiation of an unintended self-sustaining chain reaction (criticality incident) in fissile material, or the loss of control of an intended self-sustaining chain reaction are serious incidents and significant efforts are put into procedures and processes to ensure that this does not occur.

Outside of the reactors there are a number of locations at the Station in which nuclear fuel may be handled or stored, and so be susceptible to a criticality hazard. These are referred to as the fuel route. The specific areas are identified in [Ref.30]

The factors that could precipitate a criticality incident in these areas are:

- the accumulation of quantities of fissile material above safe levels according to the level of U^{235} enrichment
- the positioning of fissile material in particular configurations
- the addition of moderator materials (such as water or graphite) to the environment containing fissile materials
- the occurrence of fire in an environment containing fissile materials

All operations involving storage, handling or movement of nuclear fuel on-site, which could conceivably constitute a criticality hazard (except when resident in the reactors), are carried out in accordance with the requirements of Criticality Safety Certificates (CSC) as part of the Criticality Safety Case. The CSCs control all the factors above to ensure that unintended self-sustaining chain reactions do not occur.

The reactor core generates the heat required to produce the stream for the turbo-generators required for electricity generation. The heat is produced by a controlled self-sustaining chain reaction in the reactor fuel. The reactor is controlled with a series of Control Rods. Each reactor has a set of 89 independent control rod assemblies (CRAs).

The safety related functions of the CRAs are:

- to shut down the reactor when required
- to maintain a shutdown condition
- to regulate reactor power
- to control reactor fuel channel gas temperature
- to maintain reactor pressure boundary [Ref.32]

Whilst highly unlikely, the failure of the CRAs to engage in the reactor core when required could lead to a loss of control of the intended self-sustaining chain reaction. The reactor design includes backup shutdown systems to mitigate against failure of the control rod system [Ref.33].

4.11 Management systems and staffing arrangements

The EDF Energy Nuclear Generation Ltd (NGL) management system describes how we manage the business and in doing so it:

- Defines how the management system integrates safety, health, environmental, security, quality and economic objectives to ensure that safety is not compromised. The management system draws on best practice, as defined within the International Atomic Energy Agency (IAEA) Safety Requirements No. GSR-3, The Management System for Facilities and Activities, together with BS EN ISO 9001, Quality Management Systems Requirements, BS EN ISO 14001, Environmental Management Systems – Requirements With Guidance For Use, BS OHSAS 18001, Occupational Health and Safety Management Systems - Requirements and BS ISO 55001, Asset Management, Management System – Requirements.

- Supports the achievement of the two general aims of a management system, as stated by the International Nuclear Safety Group on 'Management of Operational Safety in Nuclear Power Plants' INSAG-13:
    - To improve the safety performance of the organisation through the planning, control and supervision of safety related activities in normal, transient and emergency situations.
    - To foster and support a strong safety culture through the development and reinforcement of good safety attitudes, values and behaviour in individuals and teams so as to allow them to carry out their tasks safely.

The station Management System used at Torness Power Station is developed to enable the Station Director to fulfil their responsibilities to direct and monitor all activities associated with the production of electricity – with nuclear safety being our overriding priority - in accordance with the Nuclear Site Licence, Statutory Requirements and Company policies, standards and procedures.

The Station Management System applies to all activities carried out by, or on behalf of, Torness Power Station. It is designed to demonstrate EDF Energy Nuclear Generation Limited's (NGL) capability to generate electricity (our product) safely and reliably in compliance with applicable legal, statutory and regulatory requirements.

The Site Licence requires the responsibilities of each member of the Torness management team be defined within a quality assurance programme for matters that affect nuclear safety.

Authority for Station operation to the requirements of the Nuclear Site Licence is delegated by the EDF Energy Nuclear Generation Limited Board (NGLB) through the Regional Chief Nuclear Officer to the Station Director. Torness Power Station Director is responsible to the Regional Chief Nuclear Officer, Region 2.

The Station Management is divided into fifteen departments:

- Operations
- Maintenance
- Work Management under the overall control of the Plant Manager
- Supply Chain
- Security
- Fuel Route
- Outage Management

- Engineering
- Technical and Safety Support
- Continuous Improvement
- Training
- Human Resources
- Finance
- Projects
- Lifetime Strategy Management

Station Director

The Station Director is:

- Responsible to the Regional Chief Nuclear Officer (Region 2) for ensuring that the Station Management System is established, documented, implemented, maintained, assessed and continually improved to meet stakeholder requirements
- Responsible for all aspects of the management of the station assets to deliver safe and reliable operation to meet plan targets and for bringing forward proposals for future resource deployment, asset operation, maintenance and improvement for incorporation into agreed Business Plans

Technical & Safety Support Manager (TSSM)

The TSSM is appointed by the Station Director as the Management Representative to support, develop and promote the Management Systems irrespective of other responsibilities and is responsible for:

- Ensuring that station management system arrangements align fully with company requirements and are implemented, maintained, monitored, audited and reviewed to assure their ongoing effectiveness
- Reporting the performance of the management system to the Station Director and recommending any requirement for improvement
- Acting as the single point of contact to oversee the Office for Nuclear Regulation (ONR) interactions

Engineering Manager

The Engineering Manager is responsible for:

- Providing support, guidance and assistance to all departments in the development, implementation and continual improvement of those parts of the management system directed to asset management
- Implementing and maintaining the site asset registers
- Reviewing the effectiveness of and identifying best practices and areas for improvement in the asset management aspects of the management system
- Providing the Station Director with reports on asset management performance

Station Lead Team

The responsibilities, accountabilities and authorities of members of the Station Lead Team are identified in Company and Station procedures and documents available via the Configured Document Management System (CDMS).

Additional services for the Station are provided by the Central Technical Organisation (CTO) including Asset Management, Central Engineering Support, Design Authority, Lifetime and Fleet Programmes, Projects, Supply Chain, Finance and Human Resources. Safety and Assurance provide Environmental Regulation and Oversight, Nuclear Fuel and Liabilities, Emergency Preparedness and Independent Nuclear Assurance (INA).

Staffing

Each department has a team of personnel, all of whom are suitably qualified and experienced for the work which they are expected to perform. The minimum required manning levels are fully documented in the departmental instructions.

A continuous shift system is operated at Torness which ensures that there are adequate staff resources available at all times to operate the Site safely and to deal with any emergency situation which might arise. The level of staffing has been underwritten by a human factors assessment, which was undertaken as part of the probabilistic safety assessment.

Procedures

It is a requirement of the Nuclear Site Licence that adequate quality assurance arrangements are made and implemented for all matters that may affect safety. These arrangements are specified in the top tier of a multi-tiered system, and define the requirements for procedures and instructions across the Site. The lower levels are described below.

The top tier requirements for procedures and instructions are further developed on a departmental or system basis. Each system or department leader is responsible for the preparation and issue of sufficient instructions to enable work to be carried out to maintain safety is adequately controlled.

Conditions for the safe operation of the plant, and the work needed to maintain the plant in a safe and reliable condition, are specified in a range of documents and arrangements.

Regulatory Control

The Nuclear Industry is regulated by the Office for Nuclear Regulation (ONR) which has at least one inspector assigned for each licensed site. These inspectors have the right to inspect any equipment or procedure at short notice and the right to require the Company to provide information. The ONR can direct the shutdown of any process that it considers unsafe.

The ONR require that the safety of plant and operations is considered in a systematic manner at all stages from planning, building, operating and decommissioning and that the safety case is subject to both continuous review and formal periodic review.

Any significant changes in procedures, plant or management structure has to be approved by the ONR before the event, in accordance with nuclear site licence arrangements.

Emergency Organisation

Torness has on-site emergency arrangements [Ref.46 & 47] that ensure that suitably qualified and experienced people are available at all times to respond to any events that cause the reactors or other equipment to deviate from their normal operating conditions. The provision of emergency arrangements can further mitigate the probability of a major release of radioactivity to the environment. Should a release of radioactivity occur, the off-site emergency arrangements are focused on implementing countermeasures to prevent the exposure of the public to radiation.

The local Police, Fire and Ambulance services form part of the integrated response to a site emergency. Mitigation actions carried out by the fire service would include firefighting, search and rescue and support to teams carrying out tasks in breathing apparatus. In providing assistance it is expected that emergency exposures may be required for Fire service intervention staff because of the proximity or duration of tasks to sources of radiation. Due to the nature of their role, it is not expected that emergency exposures would be required for Police personnel.

The emergency plans, both on-site and off-site, for Torness are approved by the ONR and exercised regularly. Consultation and development of best practice in emergency planning for nuclear sites is discussed at consultation meetings involving key stakeholders. The BEIS led Nuclear Emergency Planning Development Committee (NEPDC) provides national guidance and co-ordination, and the Nuclear Emergency Arrangements Forum (NEAF) is a forum for operators to share practices. Locally the Emergency Planning Consultative Committee (EPCC) meets regularly to coordinate local plans, to allow consultation on changes, and acts as a focal point for planning issues.

4.12 Local population information

This information has been obtained from the Torness Power Station Off-Site Plan [Ref.34].

Residential

Based on information gathered by Police Scotland there are a total of 377 residents with an additional regular population of 30 at an outdoor education centre in Innerwick.

The major residential settlements are as follows:

Name	Zone	Population (2007)
Birnicknowes	F3	36
Braidwood	H3	5
Crowhill	H2	22
Innerwick	I3	188 (+30 outdoor centre)
Thornton	G2	36

There are an estimated 11,000 residents within 3-15km of the site. Detailed information on vulnerable populations within the DEPZ can be found in the Off-Site Emergency Plan.

Transient

There is a camping/caravan site at Thorntonloch which could have up to 50 residents during summer months. In addition, there are 2 major footpaths in the area which could have a sizeable transient population using them especially during summer months. These are Boarders Coastal Path and the North Sea Trail.

Commercial

Within the DEPZ the largest commercial population is that of the employees and contractors on the Torness Station site. The workforce details are as follows:

- In Hours: [Removed]
- Out of Hours: [Removed]

4.13 The area likely to be affected by the dispersal of radioactive substances

Dispersal for the "reference release"

This section identifies the area likely to be affected in the event of an incident up to and including the reference release as identified in section 4.8. The area of likely dispersion has been examined in detail in the document "The AGR REPPIR Reference Release - Evaluation of Off-Site Doses" [Ref.35].

The report presents an evaluation of doses as a function of downwind distance for the AGR Reference Release for comparison to the 5mSv effective dose criterion in REPPIR and the ERLs for early countermeasures to protect the public. It also considers the downwind distance to the Council Food Intervention Levels (CFIL) in order to estimate the potential extent of food bans. It uses the same methodology and evaluates many of the same quantities as were considered most recently for Sizewell B and so extends and supersedes the earlier analyses for the AGRs carried out at the time of the introduction of REPPIR.

The methodology includes the extension applied after the methodology for Sizewell B [Ref.36] was produced to include the potential ingestion doses incurred in the first 24 hours which was required by the ONR since the Health and Safety Executive (HSE) guidance on REPPIR [Ref.37] states that early health protection measures should be disregarded in this period and this is taken to include food bans.

Average dispersion conditions are required for the purposes of the assessment for the 5mSv effective dose criterion for REPPIR and so Pasquill Category D conditions have been used. Therefore, the accepted representative values for this category of a wind speed of 5m/s and a mixing layer height of 800m have been used [Ref.38].

A release duration of 5 hours is implicit in the specification for the reference release [Ref.22 &39]. The duration of dispersal matches the release duration.

For the worst reasonably foreseeable accidents (bounded by the reference release) the following downwind distances have been determined:

a. The 5mSv effective dose contour, evaluated for 1 year using average, category D, dispersion conditions for the purposes of REPPIR, extends out to about 870m. It has been shown that the equivalent doses to the lens of the eye or the skin are less onerous than the effective dose

b. The short term effective dose falls to 3mSv, the lower ERL for sheltering, at about 680m under average dispersion conditions and at about 1600m under pessimistic, category F, dispersion conditions

c. The short term effective dose falls to 30mSv, the lower ERL for evacuation, at about 180m under average dispersion conditions and at about 230m under pessimistic dispersion conditions

d. The 500Bq/kg Council Food Intervention Level (CFIL) for iodine activity applicable to milk is estimated to occur out to about 43km under average dispersion conditions and out to about 44km under pessimistic dispersion conditions. The extent of the area corresponding to the 1000Bq/kg CFIL applicable to caesium activity in milk is very much smaller

Dispersal beyond the "reference release"

Whilst the information in section 4.13.1 above identifies the impact of the reference release, which can be considered reasonably foreseeable, REPPIR requires the consideration of radiation emergencies which go beyond the limits of reasonably foreseeable.

Significant work has been undertaken for national projects to identify plant faults and source terms that go well beyond those specifically identified under the reference release [Ref.40].

These sets of severe accident source terms include a range of postulated releases that increase in magnitude from the worst reasonably foreseeable accidents specified for REPPIR up to releases of significant fractions of the radioactive inventories.

Durations of these postulated releases range into tens of hours as set out in Table 3 of [Ref.40]. 13 Source Terms for a range of severe accident scenarios are identified. The content of the document is classified Official-Sensitive and therefore not replicated in this report.

The derived source terms will enable the assessment of off-site dispersal distances in extreme scenarios through the incident assessment tools.

4.14 Likely exposures to ionising radiation

Effective dose for the "reference release"

In line with the assessment summarised in section 4.13.1 above, a number of tables have been produced which demonstrate the effective dose versus the downwind dispersal distance.

The calculated doses do not account for any countermeasures within the first 24 hours as required by REPPIR. The tables for effective and equivalent dose are shown below. A full list of dose tables is set out in [Ref.35].

Table 1: Effective Dose as a Function of Downwind Distance for the REPPIR 5mSv Dose Contour for the AGR Reference Release

Downwind Distance (m)	Effective Dose (mSv)		
	Adult	**Child**	**Infant**
50	71.1	106.6	155.7
100	55.6	83.2	121.2
150	43.9	65.6	95.3
200	20.5	30.5	44.3
250	9.8	14.5	21.1
300	8.2	12.2	17.7
350	7.0	10.4	15.1
400	6.1	9.0	13.0
450	5.3	7.9	11.4
500	4.7	7.0	10.1
550	4.2	6.2	9.0
600	3.8	5.6	8.1
650	3.4	5.1	7.3
700	3.1	4.6	6.6
750	2.8	4.2	6.1
800	2.6	3.9	5.6
850	2.4	3.6	5.1
900	2.2	3.3	4.7
950	2.1	3.1	4.4
1000	1.9	2.9	4.1
2000	0.7	1.0	1.5
3000	0.4	0.5	0.8
Interpolated Distance to 5mSv (m)	480	660	870

Table 2: Equivalent Dose to Lens of Eye and Skin as a Function of Downwind Distance for the REPPIR Dose Contour for the AGR Reference Release

Downwind Distance (m)	**Equivalent Dose to Lens of Eye and Skin (mSv)**		
	Adult	**Child**	**Infant**
50	32.68	45.36	58.00
100	26.81	37.22	47.60
150	21.88	30.40	38.87
200	10.45	14.52	18.57
250	5.08	7.06	9.03
300	4.34	6.03	7.71
350	3.75	5.21	6.67
400	3.28	4.56	5.83
450	2.90	4.03	5.15
500	2.58	3.59	4.59
550	2.32	3.22	4.12
600	2.09	2.91	3.72
650	1.90	2.65	3.38
700	1.74	2.42	3.09
750	1.60	2.22	2.84
800	1.47	2.05	2.62
850	1.36	1.89	2.42
900	1.26	1.76	2.25
950	1.18	1.64	2.09
1000	1.10	1.53	1.95
2000	0.41	0.57	0.73
3000	0.22	0.30	0.39
Interpolated Distance to 15mSv (Eye) (m)	180	200	220
Interpolated Distance to 50mSv (Skin) (m)	n/a	n/a	88

Calculated dose beyond the "reference release"

As stated in section 4.13.2 REPPIR requires the consideration of the impacts of radiation emergencies that go beyond what is considered reasonably foreseeable.

As part of the work to identify source terms for the severe accident faults used in national hazard assessment projects, the radionuclide release for the identified severe faults has been identified as per tables 7-20 of [Ref.40]. This includes the percentage contribution to total dose for each radionuclide.

When applied through incident assessment tools this will allow for calculation of effective dose based on the current weather conditions.

4.15 The necessity for an Operator Emergency Plan

As a result of the assessments carried out by EDF Energy, and reported in sections 4.13 and 4.14 above, it is apparent that the Reference Release (the reasonably foreseeable accident with the largest consequences off-site), with no application of countermeasures would result in an effective dose of at least 5mSv in a 12 month period, and would therefore be classed as a Radiation Emergency under the REPPIR regulations. As a result of this definition, an Operator's Emergency Plan is required under REPPIR. Notwithstanding this assessment, EDF Energy is also required under the Site Licence to prepare an Operator's Emergency Plan.

5. Definitions

AGR	Advanced Gas-cooled Reactor
ALARP	As Low As Reasonably Practicable
BEIS	Business, Energy & Industrial Strategy
CFIL	Council Food Intervention Level
DB	Dose Band
DBF	Design Basis Fault
DBUEG	Deployable Back Up Equipment Guidelines
DEPZ	Detailed Emergency Planning Zone
EEPZ	Extended Emergency Planning Zone
EPCC	Emergency Planning Consultative Committee
ERL	Emergency Reference Level
HIRE	Hazard Identification & Risk Evaluation
HS&E	Health Safety & Environment
HSWA	Health & Safety at Work Act 1974
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IFDF	Irradiated Fuel Disposal Facility
IFTF	Irradiated Fuel Transport Flask
LPBUCS	Low Pressure Backup Cooling System
NEAF	Nuclear Emergency Arrangements Forum
NEPDC	Nuclear Emergency Planning Delivery Committee
NEPLG	Nuclear Emergency Planning Liaison Group
NSC	Nuclear Safety Committee
NSP	Nuclear Safety Principles
OD	Ordnance Datum
ONR	Office for Nuclear Regulation
PCPV	Pre-stress Concrete Pressure Vessel
PHE-CRCE	Public Health England – Centre for Radiological and Chemical Hazards
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations 2001
RoA	Report of Assessment
SAG	Safety Accident Guidelines
SAP	Safety Assessment Principles
SBERGs	Symptom Based Emergency Response Guidelines
SOIs	Station Operating Instructions
SRV	Safety Relief Valve
WENRA	Western European Nuclear Regulators' Association
Station Abbreviation Used TOR	Torness Power Station

6. References

Ref No.	Doc No.	Doc Title
1	SPARE	SPARE
2	ISBN 978 0 7176 2240 5	A guide to the Radiation (Emergency Preparedness and Public Information) Regulations 2001
3	N/A	Japanese earthquake and tsunami: Implications for the UK Nuclear Industry by HM Chief Inspector of Nuclear Installations – Interim Report (May 2011).
4	N/A	Japanese earthquake and tsunami: Implications for the UK Nuclear Industry by HM Chief Inspector of Nuclear Installations – Final Report (September 2011)
5	N/A	IAEA International Fact Finding Expert Mission of the Fukushima Dai-Ichi NPP Accident following the Great East Japan Earthquake and Tsunami. June 2011.
6	T/AST/082 – Issue 1	Technical Assessment Guide: The Technical Assessment of REPPIR Submissions
7	Statutory Instrument 2001 No. 2975	The Radiation (Emergency Preparedness and Public Information) Regulations (REPPIR) 2001
8	http://www.metoffice.gov.uk/climate/uk/regional-climates/es	Eastern Scotland Regional Climate Summary (as of February 2017)
9	Removed	
10	Removed	
11	Removed	
12	Removed	
13	https://ukinventory.nda.gov.uk/	UK Radioactive waste Inventory
14	Removed	
15	Removed	
16	https://osmaps.ordnancesurvey.co.uk/	UK Ordnance Survey Mapping
17	Removed	
18	Removed	
19	Removed	
20	Removed	
21	Removed	
22	Removed	
23	SPARE	SPARE
24	Removed	
25	Removed	
26	Removed	
27	Removed	
28	Removed	

29	Removed	
30	Removed	
31	SPARE	SPARE
32	Removed	
33	Removed	
34	N/A	Torness Off-Site Emergency Plan Sep. 2016
35	Removed	
36	Removed	
37	ISBN 978 0 7176 2240 5	A guide to the Radiation (Emergency Preparedness and Public Information) Regulations 2001
38	NRPB-R91	A Model for Short and Medium Range Dispersion of Radionuclides Released to the Atmosphere
39	Removed	
40	Removed	
41	Removed	
42	Removed	
43	Removed	
44	Removed	
45	Removed	
46	Removed	
47	Removed	
48	BEG/POL/006	Nuclear Generation Nuclear Safety Policy